Report for 2001DE3681B: Graduate Fellowship in Water Quality: Baseflow and Storm Discharges of Nutrients to Delaware’s Inland Bays

- Water Resources Research Institute Reports:
    - Jennings, Jennifer; William Ullman, and Joseph Scudlark, March 2002, Annual report to DWRC: "Land Use/Land Cover and Nutrient Discharges to Delaware’s Inland Bays", Delaware Water Resources Center, University of Delaware, Newark, DE, 14 pages.

Report Follows:

Basic Information: Fellow Project #3 (of 3)

Title:	The Role of Land Use and Land Cover in the Delivery of Nutrients to Delaware's Inland Bays
Project Number:	G-03
Start Date:	3/1/2001
End Date:	2/28/2002
Research Category:	Water Quality
Focus Category:	Water Quality, Nutrients, Non Point Pollution
Keywords:	Eutrophication, Land Use, Nitrogen, Nutrients, Rainfall-Runoff Models, Rainfall-Runoff Processes, Water Quality, Water Quality Monitoring
Lead Institute:	DE Water Resources Center
Principal Investigators:	Jennifer Jennings, William Ullman ullman@udel.edu, Joseph Scudlark scudlark@udel.edu

Publication

1. Jennings, J., W. Ullman, and J. Scudlark. Annual report to DWRC, March, 2002. Land Use/Land Cover and Nutrient Discharges to Delaware's Inland Bays. College of Marine Studies, University of Delaware, Newark, DE.

Names and degree level (highest level during the reporting period) of all students who worked on the research project: Jennifer A. Jennings, PhD candidate

Background/Justification

Many coastal plain estuaries within the mid-Atlantic region of the United States suffer from eutrophication. This nutrient over-enrichment is caused by elevated nutrient loadings from domestic, municipal, industrial, and agricultural practices in the surrounding watersheds. Surface and ground water discharges from uplands, atmospheric deposition, and in some cases inputs from the coastal ocean, are responsible for the delivery of nutrients to estuaries. In the estuary, nitrogen and phosphorus fertilize vegetation leading to high levels of plant production, changes in phytoplankton species, and potentially noxious and toxic algal blooms. Eutrophication can have several other adverse effects on the ecosystem including decreases in dissolved oxygen concentrations, reduced biodiversity, and fish and shellfish kills.

Although fairly extensive research has been done in the identification of nutrient sources, there is little definitive proof concerning the role of the watershed, if any, in the attenuation and delivery of nutrient loads from upland land uses to the estuary. In 1998, a study estimated nitrogen loading rates for various land use classes and atmospheric deposition, as well as loadings from point sources in the watershed, to compile total loading values to Delaware's coastal bays. These estimated loadings however, were not verified by comparison to actual measurements.

Objectives

1. Test the 1998 study results at one sub-watershed of Delaware's Inland Bays, Bundicks Branch

The Role of Land Use and Land Cover in the Delivery of Nutrients to Delaware's Inland Bays
(Objectives, continued)

2. Assign realistic uncertainties to interpolated baseflow loadings through intensive sampling

3. Determine and include annual storm loads in the estimates of total nutrient loading and examine the seasonal and inter-annual variability

4. Determine the impact of indirect atmospheric deposition and within sub-watershed attenuation factors on total nutrient loads

Methods

Objective 1. Testing the 1998 study approach.

Geographic information systems (GISs) have been used to determine the areas of the various land use and land cover types within Bundicks Branch. These areas were then multiplied by corresponding loading factors, in the 1998 study estimates, to calculate the theoretical N-load due to the land use and land cover from the studied sub-watershed. The values computed will be compared to the loads derived from the sampled data from Bundicks Branch, which will be used to determine the tributary's annual total nutrient loads.

Objective 2. Assignment of uncertainties to baseflow loadings.

Daily baseflow loads of the particulate and dissolved constituents are desired for the entire sampling period at Bundicks Branch so that monthly, quarterly, and annual loadings can be estimated. The annual loads will later be used to test the 1998 approach. In order to compute these values, nutrient concentration data must be generated by linear interpolation between the bimonthly baseflow sampling dates. Loadings can then be computed by multiplying these concentrations by mean daily discharges. In doing this though, it is assumed that the mean daily discharge will accurately represent the discharge, and hence the loadings, over an entire day, and that a linear interpolation will correctly represent the fluxes in concentration and loading between samplings. These assumptions must be validated however and for their future use in management purposes, realistic uncertainties must be assigned to the calculated baseflow loadings. To achieve this, daily and monthly variations in nutrient concentrations will be investigated through more intensive sampling.

Objective 3. Determination and inclusion of annual storm loads.

Annual storm loads will be estimated with the use of storm water samples collected between May 1999 and April 2000 and May 2001 and April 2002. Three methods of making this estimate are under evaluation. In the first approach, correlations between water discharge and nutrient concentration are examined. The second method involves the application of a ratio of the amount of precipitation that occurred during the monitored storms to the total amount of precipitation in the one-year sampling periods. Finally, the third method under evaluation is designed to take into account the seasonal influences on nutrient loads and is based on the simple relationship that the total load is the sum of the baseflow and runoff (storm) loads. All three methods will undergo further scrutiny to determine if one, or a combination of the three, produce the best estimate of annual storm loads. These data sets will also be examined for seasonal variations in storm loads and with the addition of the second storm data set the inter-annual variability of storm loads can be determined. Once this has been completed, the annual storm loads at Bundicks Branch can be added to the annual baseflow loads and used to test the 1998 method at this particular site.

Objective 4. Determination of indirect atmospheric deposition and within sub-watershed attenuation factors.

The proposed comparison to test the 1998 method of determining nutrient loads to an estuary may find that this approach produces accurate estimates, but perhaps a more inclusive approach would include indirect atmospheric deposition and within sub-watershed attenuation factors as well. The final objective of the proposed research project is to develop estimates of the nutrient deposition and attenuation rates within the Inland Bays sub-watersheds. Monthly totals of dissolved inorganic nitrogen (NO_3 and NH_4^+) in the rainfall collected at Cape Henlopen State Park have been made available and were used to estimate the indirect atmospheric deposition, which fell over Bundicks Branch during the study period. With the addition of the indirect atmospheric deposition component to the point source and land use loading factors from the previous method and the use of the compiled baseflow and storm data, a within sub-watershed attenuation factor can be back-calculated. More specifically, the input terms can be subtracted from the total stream loadings, which represent the total value exported from the watershed to the estuary, to determine the magnitude of the output term.

Results to date

- Using ArcView GIS and the 1998 study's land use classifications and corresponding loading factors, the theoretical N-load due to the land use and land cover from Bundicks Branch to Rehoboth Bay was determined. This method results in a load of 111 kgN/day. Similar calculations have been made for other sub-watersheds in the Inland Bays Basin.

- All samples from the every-hour-for-a-day and every-day-for-a-month sampling projects have been analyzed for the desired parameters and loads have been calculated. It appears from the hourly and daily sampling, that baseflow discharges can be sufficiently well characterized by biweekly water sampling and mean daily discharges.

- The storm water sampling was completed in April 2002 and these samples are currently in the process of being analyzed. The analysis of these data and the determination of an appropriate method for projecting annual storm loads is incomplete.

- The annually averaged indirect atmospheric deposition rate to Bundicks Branch has been determined as 43 kgN/day, which represents 40% of the total discharge estimated in 1998.